SESSION #8
AERO ACOUSTIC ANALYSIS
AND
COMMUNITY NOISE

HSCT
CLIMB TO CRUISE NOISE ASSESSMENT

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INTRODUCTION

The widely accepted industry HSCT design goal for exterior noise is to achieve FAR Part 36 Stage 3 noise limits currently required for new subsonic aircraft. To date the HSRP has focussed research to achieve this Stage 3 noise goal.

However, noise certification is an entirely different situation compare to operating the aircraft at the world's international airports. Three takeoff operational phases must be carefully reviewed to ensure community noise acceptability after the year 2005.

The three phases of concern are: 1) airport noise abatement at communities close to the airport, 2) climb power opening-up procedures and 3) the climb to cruise phase affecting communities far from the airport shown in Figure 1 below:

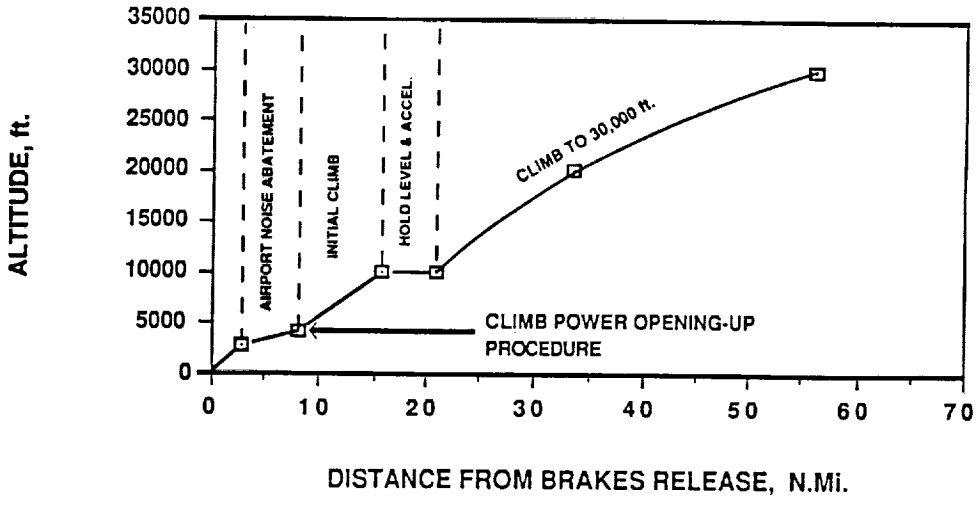


FIGURE. 1.- TYPICAL HSCT TAKEOFF PROFILE

DEFINING A POTENTIAL CLIMB NOISE PROBLEM

Now the stage has been set regarding takeoff operational procedure phases that could affect community noise reaction the issue of noise level and number of operations has to be addressed. The FAA have issued guidance on air route changes which gives insight into defining the climb to cruise problem.

Firstly, it has been determined that a 5dB increase in sound exposure level for a given minimum number of aircraft overflights will likely to cause significant complaints.

This determination has been based primarily on the operations of Stage 2 aircraft. If no Stage 2 aircraft operate at a given airport 5% of the Stage 3 operations are used to determine community noise acceptability. The minimum number of operations are reduced, regarding compliants, as the residential community moves from noisy urban to quiet suburb areas as shown in Table 1 below.

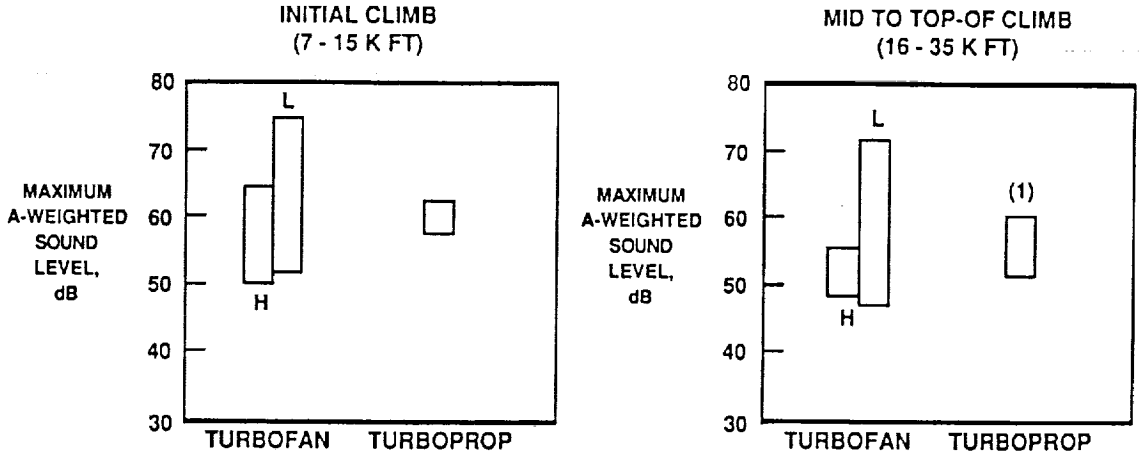
TABLE 1. Minimum Number of Daily Operations by Large Jet Airplanes (>75,000 lbs) on the Affected Route

Aircraft Altitude (ft.,AGL)	Departures — Residential Community (See table below)				Arrivals — Residential Community (See table below)			
	Quiet Suburb	Normal Suburb	Urban	Noisy Urban	Quiet Suburb	Normal Suburb	Urban	Noisy Urban
3000	2	7	22	68	65	205	>500	>500
5000	6	20	63	198	198	>500	>500	>500
10000	34	109	343	>500				
15000	109	343	>500	>500				

Residential Community	Description
Quiet Suburb	Single family detached dwellings on large lots
Normal Suburb	Single family detached dwellings on 1/4 to 1/3 acre lots
Urban	Multi-family dwellings (apartment buildings, row housing, ect.)
Noisy Urban	Multi-family dwellings (high rise apartments) near busy roads or industrial areas

PAST UHB EXPERIENCE

In the early 1980's the aerospace industry assessed the ultra high bypass engine (UHB) powered aircraft for noise acceptability and economic viability. The UHB aircraft were compared to the existing subsonic fleet regarding climb to cruise and cruise noise. The subsonic fleet were categorized into three categories: 1) high by-pass ratio engine, 2) low by-pass ratio engine and 3) turboprop. The noise data for these categories were obtained from USA and European data bases and a summary of the data is shown in Figure 2 below. The range of noise levels in dBA show the low bypass ratio engine (Stage 2 equivalent) to be significantly higher than the high bypass ratio engine (Stage 3 equivalent). It should be noted that the Stage 2 fleet is likely to be retired after 2005 based on phase out regulations currently being discussed by the regulatory agencies.



H - HIGH BYPASS RATIO ENGINE
L - LOW BYPASS RATIO ENGINE
(1) TURBOPROP POWER SETTING UNCERTAIN

FIGURE. 2.- SUBSONIC CLIMB NOISE DATA

CONCORDE MEASURED INITIAL CLIMB NOISE LEVELS

Since 1975 Concorde has been operating regularly from London (Heathrow), Paris (Charles De Gaulle), New York (JFK) and Washington (Dulles). There exists an abundance of noise measurements, particularly over the early years, of Concorde initial climb operations. USA Department of Trade and UK Civil Aviation Authority Reports show that Concorde operations are significantly higher than the current subsonic fleet as shown in Figure 3 (Reference 1). This shows that for 15 years the community at distances 20km and 30km from LHR have received noise from Concorde in excess of 20 PNdB above the 747 and Tristar fleet. As the number of Concorde operations at LHR have typically been 5-6 per day the number of complaints have been minimal in later years. However, if the number of operations increased significantly the picture on community noise acceptance could change dramatically.

Also it should not be assumed that other communities around international airports having 5-6 Concorde operations per day would accept the same situation. For comparison in dBA an exchange rate of approximately dBA = PNdB -11 should be used for these conditions.

At Washington (Dulles) airport the communities at 20 and 30 kilometers from the airport objected initially to Concorde noise during the power opening up operations, after the noise abatement phase, such that the procedure had to be adjusted to gradually increased power.

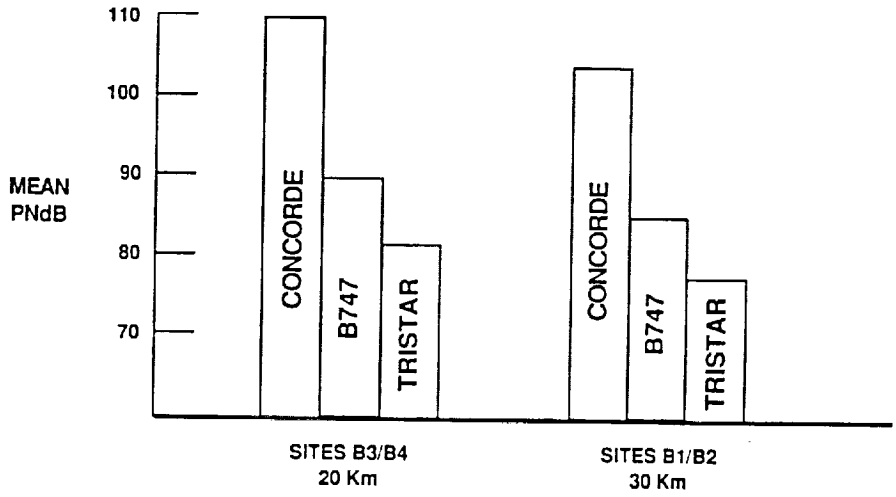


FIGURE. 3.- LONDON (HEATHROW NOISE MEASUREMENTS)

HSCT
CLIMB POWER OPENING-UP PROCEDURES

As mentioned before there has been some past problems with Concorde during the engine power opening-up phases on climb-out. It has been estimated that the HSCT increase in noise from 4% climb gradient power, used during airport noise abatement, to climb power is approximately 7dBA in the suppressed exhaust condition. This would increase to 27dBA if the noise suppression is removed. Therefore it may be necessary to produce a segmented power opening-up procedure at some airports to minimize community noise impact. This is illustrated below in Figure 4 by showing engine power requirements and aircraft profile.

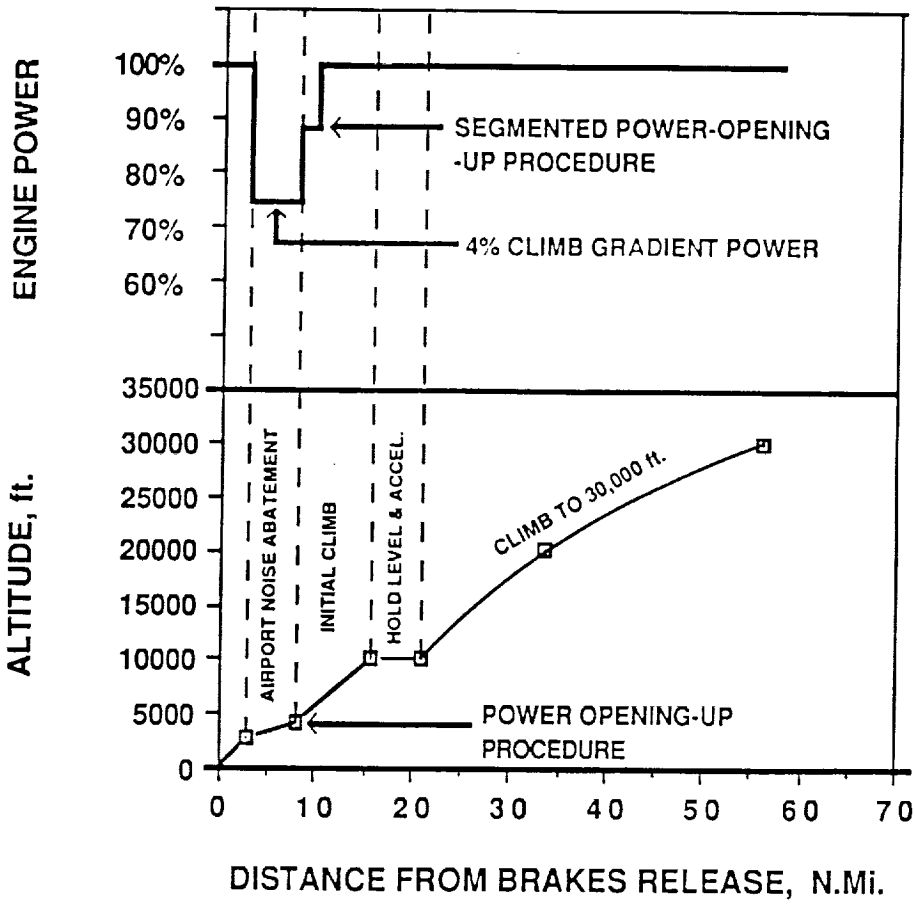


FIGURE. 4.- INITIAL CLIMB-OUT PROCEDURE

HSCT
CLIMB TO CRUISE NOISE ASSESSMENT

To date DAC has attempted to evaluate the climb to cruise noise of two HSCT engine cycles on a Mach 3.2 configuration. Further assessments at Mach 2.2 and 1.6 will be conducted under a new system study contract. The noise results for the P&W-TBE with a mixer/ejector nozzle in the unsuppressed mode are presented below in Figure 5. A typical takeoff mission profile is shown. An acceleration phase at 10,000 ft is used to achieve Mach 0.7 before a further climb is initiated to achieve Mach 0.98 at 30,000 ft.

Our existing jet noise prediction codes for mixing and shock noise is only validated by measurements in a restricted operating envelope, typically up to NPR = 3.5, Tj = 2,500K, M = 0.35. Altitude = 10,000 ft. As can be seen in Figure 5, large extrapolations are necessary to conduct the HSCT climb to cruise noise assessment. Three standards of jet noise prediction have been assessed: 1) mixing only, 2) mixing plus shock (no flight effects) and mixing plus shock with convective amplification due to forward speed effects. As can be seen some extremely high noise levels are predicted particularly if shock noise is estimated using current codes. From this point in the discussion only jet mixing noise will be considered.

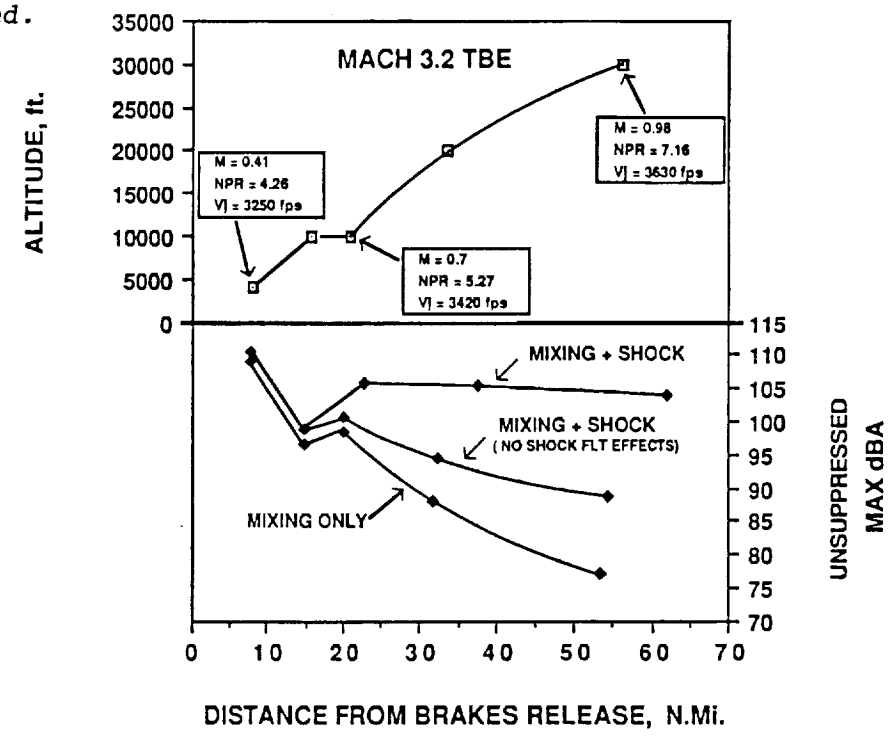


FIGURE. 5. - HSCT CLIMB TO CRUISE NOISE PREDICTIONS

HSCT
COMMUNITY NOISE CONCERNS
AFTER YEAR 2005

It is likely that the Stage 2 subsonic fleet will be virtually retired by 2005. This means that the communities will be virtually unaffected by the remaining Stage 3 aircraft at large distances from the airport. The introduction of HSCT operations are likely to impact the far out communities as the current prediction levels are well in excess of the current subsonic Stage 2 and Stage 3 fleet (see Figure 6). This indicates that noise suppression is likely to be required upto 30,000 ft. altitude.

The data presented below is based on peak single event dBA noise levels under the aircraft flight path. If only the Stage 3 subsonic fleet remains after 2005, having acceptable climb to cruise noise levels, it is clear that the introduction of HSCT operation will increase the noise exposure level at an alarming rate, well in excess of a 5dB increase, based on earlier discussions.

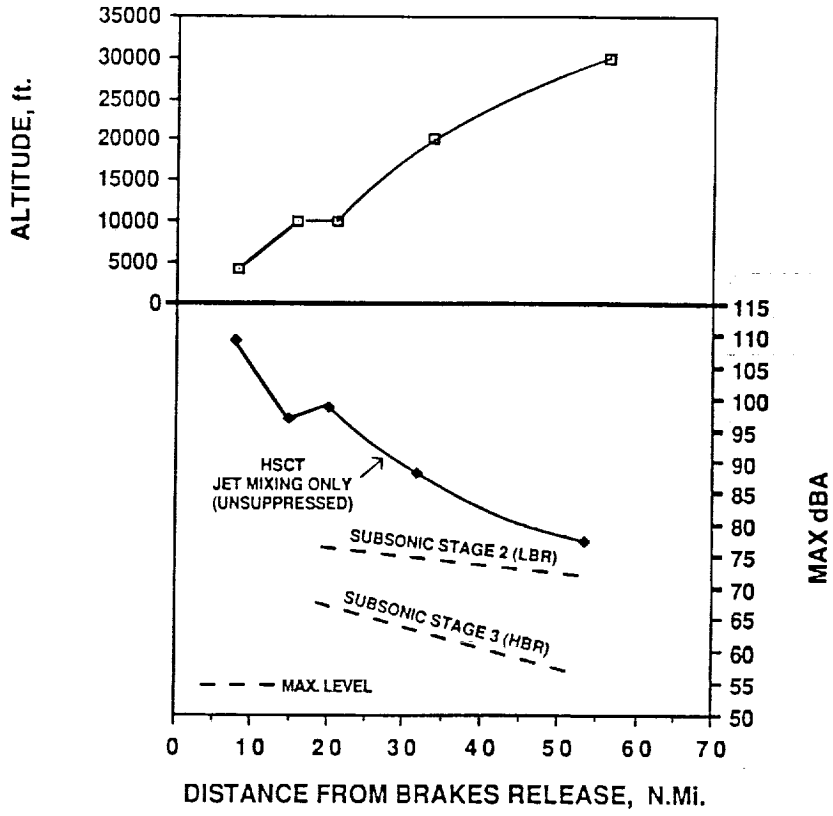


FIGURE. 6.- CLIMB NOISE HSCT VS SUBSONICS

JET NOISE PREDICTION CONCERNS

It is a concern at this time that the current HSCT noise prediction codes for climb to cruise noise are inadequate, particularly in predicting shock noise. The HSCT engine cycles have increased exhaust pressure ratios and total exhaust temperatures compared to those validated in the existing subsonic aircraft jet noise prediction codes. This also raises some doubt about the validity of the jet mixing noise estimates for HSCT.

Therefore there is an urgent action to evaluate the need for a flight test data base to extend the existing jet noise data base. The new flight data base should encompass the flight conditions and envelope shown Figure 7 below. The question of an existing suitable flight test vehicle needs to be reviewed and discussed with the acoustic specialists.

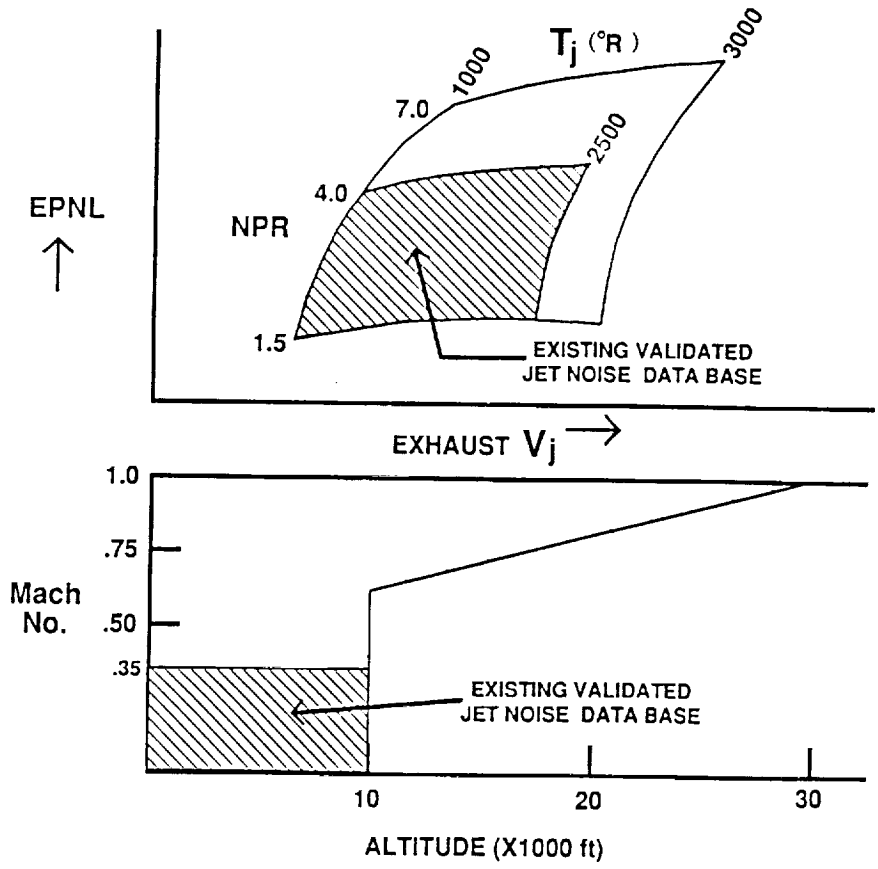


FIGURE .7.- REQUIRED HSCT TEST DATA ENVELOPE

CONCLUSIONS

- The existing Stage 2 subsonic fleet is likely to be phased out by the time the HSCT operates in significant numbers.
- Current unsuppressed HSCT climb to cruise noise levels, considering jet mixing noise only, are higher than the maximum levels of existing Stage 2 subsonic aircraft.
- The Stage 3 subsonic fleet noise exposure level will be significantly lower than the unsuppressed HSCT levels. However, the Stage 3 fleet may not be the measure for community noise acceptance of the HSCT.
- After the year 2005 it is likely that significant noise suppression upto 30,000 ft. altitude will be required for the HSCT engine cycle in order to operate from some international airports.
- If jet shock noise becomes dominant during the climb to cruise phase the problem will significantly escalate.
- The current noise prediction codes for HSCT climb to cruise noise are inadequate and not validated.

HSCT CLIMB TO CRUISE NOISE ASSESSMENT RECOMMENDATIONS

- *Extend in-flight jet noise data base to include HSCT climb to cruise noise conditions.*
- *Evaluate suitable existing flight test research vehicle*
- *Determine an acceptable increase in community noise exposure level after the Stage 2 subsonic fleet has been retired (after 2005?) i.e. re. Stage 3 subsonic fleet or background level.*

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